REMARKS/ARGUMENTS

Favorable consideration of this application is respectfully requested. Applicant has amended claims 1, 13-23 and 25. Favorable reconsideration of this application is, consequently, earnestly solicited in view of the following remarks.

Applicant thanks Examiner Angebrandt for the telephone interview on June 26 to discuss draft amendments to claims 1 and claim 13 to overcome the cited Gaissinsky, Bukharev and Araujo references. Applicant further thanks the Examiner for the courtesy copy of the Interview Summary for use in responding to the pending office action.

While an agreement was not reached in regard to the claims, suggestions for amendments were discussed and will be considered as long as a basis for the amendment is found in the original application. Applicant agreed to submit a Glebov publication from 1984 which is attached herewith.

35 U.S.C. 112 Rejections:

Claims 1-25 were rejected under 35 U.S.C. 112, second paragraph, as being indefinite for failing to particularly point out and distinctively claim the subject matter applicant regards as the invention.

Claims 1, 13, 15 and 23 have been amended to clarify that the subject matter Applicant regards as the invention.

Claims 15-22 were rejected because they claim an apparatus not an optical element. The preamble of claims 15-22 have been amended to recite an apparatus, not an optical element.

Claim 25 was rejected because it is unclear what a mux/demux device is. Claim 25 has been amended to clarify that the device is a multiplexer/demultiplexer. Mux/demux is a commonly used abbreviation used especially in the art of electronics and telecommunications for multiplexer/demultiplexer. For example see U.S. Patent No. 6,034,968 (Abstract). A copy of the abstract is attached herewith.

35 U.S.C. 102(e) Rejection:

Claims 13 and 15-20 were rejected under 35 U.S.C. 102(e) as being fully anticipated by Gaissinsky et al. (U.S. Patent Application No. US-2003/0015509). Examiner alleges that '509 discloses all of the limitations of claims 13 and 15-20.

The Gaissinsky patent has nothing common with phase (refractive index modulation) hologram recording by external source of UV or visible radiation. First, Gaissinsky is directed to producing laser-induced breakdown in the bulk of a photosensitive glass. Breakdown results in hot plasma generation in focal spot. Further thermal development results in coloration of UV exposed volume in accordance with old Corning patents.

Claims 1-5, 10-13, 15-21 and 23-24 were rejected as being fully anticipated by Bukharev et al. and claims 15-20 were also rejected as being fully anticipated by Araujo et al. (U.S. Patent No. 4,125,404).

Bukharaev's publication described amplitude hologram recording by bleaching of color centers in glass. This hologram results from modulation of absorption coefficient of glass but not modulation of refractive index as in the subject invention. Such amplitude holograms have theoretical limit of diffraction efficiency at 4% and therefore cannot be

used for high efficiency holographic elements fabrication which is discussed in the subject application.

Araujo's patent describes a photochromic glass which changes its absorption coefficient under exposure to visible and UV radiation. This glass can be used for amplitude hologram recording with diffraction efficiency not exceeding 4% and cannot be used for holographic optical elements.

The present application uses the same type of glass that was studied in a number of patents and publications made at Corning and other research groups. The same procedure of UV exposure and thermal development as was described in the previous publications is used and the present invention has the same spectral region of photosensitivity determined by absorption band of Ce(3+) and the same chemical reactions occur.

However, there are several differences which enable recording of high efficiency phase holograms (refractive index change with minimal coloration) in the Glebov patents and patent applications contrary to recording of images (color change which means absorption and/or scattering change) as described in other publications.

The first difference is the basic of the first Glebov patent (U. S. Patent No. 6,586,141 B1. July 1, 2003). This patent teaches that decreasing of concentrations of impurities of iron and heavy metals results in decreasing of refractive index in UV exposed areas after thermal development with minimum coloration. This effect enables a procedure of high efficiency hologram recording. This feature of photo-thermo-crystallization was not disclosed by Gaissinsky ('059), Bukharev publication, or Araujo '404.

The second basic difference which is the core of the present application is that a spectral region of photosensitivity by two consequent exposures of PTR glass to radiation with different wavelengths was changed. The first exposure in the same UV region that was exploited in previous art including U.S. Patent No. 6,586,141 issued to Glebov on July 1, 2003. This exposure produces precursors of nucleation centers (Ag subzero and intrinsic color centers). The second exposure to high power visible radiation partially destroys those precursors. Therefore, after thermal development, refractive index in double exposed area is higher than in a single exposed area but lower that in unexposed area. This difference enables recording of phase hologram by illumination with a uniform UV pattern followed by illumination with an interference pattern of high power visible radiation. This process was not disclosed in prior art publications.

Claims 1, 13, 15 and 23 have been amended to clarify the composition of the PTR glass used (total contamination with metals and heavy metals below approximately 5 parts per million as described on page 12, lines 8-11) and the effects of the exposure to the UV light and the visible light source on the PTR glass (page 18, lines 3-12) (nonlinear transformation of nucleation centers – page 22, line 22 to page 21, line 1) to produce a hologram with 100% diffraction efficiency (page 18, lines 13-15). Also see the summary discussion on page 20, lines 3 to page 21, line 4.

For the reasons provided, Applicant believes that amended claims 1, 13, 15 and 23 are patentable over Gaissinsky, Bukharev and Araujo and thus, requests removal of the section 102 rejections.

Claims 1-10, 12, 13, 15-21 and 23-24 were rejected as being unpatentable under 35 U.S.C. 103(a) as being unpatentable over Araujo in view of Bukharev. For the

reasons provided above in regard to the section 102 rejections, applicant believes that claims 1-25 are allowable over the cited references.

In view of the foregoing considerations, it is respectfully urged that claims 1-25 be allowed. Such action is respectfully requested. If the Examiner believes that an interview would be helpful, the Examiner is requested to contact the attorney at the below listed number.

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Recording volume holograms in silicate glasses

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Color centers in crystals have several advantages over ordinary photographic materials for use in the recording of holograms.[1] The same advantages may be realized in glasses, which are more homogeneous and more generally available. Three-dimensional holograms were first recorded in a glass in Ref. 2, where the beam from a helium–neon laser was used to bleach radiation-induced color centers. The potassium borate glass used in those experiments, however, has certain disadvantages. Since the color centers in this glass are unstable at room temperature, the hologram disappears after a day or so. In addition, the reconstructing light bleaches the color centers and destroys the hologram. Furthermore, that particular glass is not manufactured commercially and must be specially produced. In this letter we report a study of the recording of volume holograms over a broad spectral range in silicate glasses, which are free of these disadvantages.

It has been shown elsewhere[3] that color centers in silicate crown glasses are stable[3] at room temperature and are not bleached by the beam from a helium–neon laser.[4] We accordingly studied the possibility of recording holograms in K-8 optical glass, SVV window glass, and specially produced alkali silicate glasses with a low impurity content. The samples were plane-parallel plates ~4 mm thick. They were bombarded with γ rays (~10^7 R) to form the color centers. The absorption spectrum of the stable color centers in these glasses consists of four broad and overlapping bands with λ_{max} = 230, 320, 450, and 615 nm (Ref. 5). The samples were exposed to the fourth harmonic of the beam from a single-frequency YAG:Nd laser (λ = 266 nm), a nitrogen laser (λ = 337 nm), a helium–cadmium laser (λ = 440 nm), and a helium–neon laser (λ = 633 nm). It was found that the light at these wavelengths optically bleaches the color centers. The efficiency of this bleaching falls off sharply with increasing wavelength of the exciting light. Illumination at λ = 633 nm produces a bleaching of 7–10% only at an exposure ~10^5 J/cm^2. It thus becomes possible to use light with λ = 440 nm to record the holograms and light with λ = 633 nm for nondestructive reconstruction. Special measurements verified that storage of the colored samples at room temperature for a year resulted in no significant decrease in the absorption coefficient.

The samples were exposured in copropagating beams with spatial frequencies of 30 and 2000 mm^{-1}. It has been found that the passage of light with λ = 633 nm through a part of the sample which has been partially bleached by this method gives rise to a diffraction pattern which corresponds to diffraction by a periodic structure. Consequently, a diffraction-grating hologram is recorded in the sample. The high angular selectivity of the holograms (a fraction of a degree) indicates that the recording is made over the entire thickness of the glass. The maximum diffraction efficiency reached in these experiments

TABLE I

Wavelength, nm	Glass	Exposure, J/cm^2
266	SiO_2 ~75% Na_2O ~22% CaO, ~ 3%	0.6
337	K-8	7
440	K-8	400
440	SVV	60

was 0.5%. The exposure required to record holograms with a diffraction efficiency of 0.05%–0.1% are listed in Table I. We see from this table that the photosensitivity reaches a maximum in the far-ultraviolet part of the spectrum. In order to make recordings in this part of the spectrum, however, it is necessary to use high-purity glasses without any impurity ultraviolet absorption. A comparison of the exposures for the K-8 and SVV glasses implies that the photosensitivity depends strongly on the composition, even for glasses of the same type. This strong dependence on the composition suggests that it might be possible to produce highly sensitive glasses for recording holograms. It should be noted in this connection that the diffraction efficiency depends not only on the composition of the glass but also on the γ dose and the exposure, but a special study will be required to identify the optimum recording conditions.

In some other experiments, we recorded and reconstructed holograms in oppositely directed beams at the same wavelength (λ = 440 nm). The recording of a hologram under these conditions confirms that the γ-colored glasses have a high spatial resolution (at least 5000 mm^{-1}) as a material for recording holograms. We wish to emphasize that in addition to being able to store the information for a long time these glasses can be reused for recording after being bleached by a thermal (T = 100–150°C) or optical (λ < 450 nm) method and then recolored.

In summary, these experiments demonstrate that it is possible to record holograms in γ-colored, commercially produced silicate glasses. These holograms are not bleached during reconstruction by the beam from a helium–neon laser, they have a high spatial resolution, and they can store the holograms for a long time. The effect found here might exploited for hologram recording in optical elements made of silicate glass.

[1] V. N. Sinnov, Zh. Nauchn. Prikl. Fotogr. Kinematogr. 15, 298 (1970).
[2] A. A. Bukharaev, N. I. Shyr'kov, and N. R. Yafaev, Pis'ma Zh. Tekh. Fiz. 1, 975 (1975) [Sov. Tech. Phys. Lett. 1, 421 (1975)].
[3] G. V. Dyargeevskaya, V. V. Vargin, N. A. Leko, and N. F. Orlov, Effect of Radiation on Inorganic Glasses, Atomizdat, Moscow (1980).
[4] L. B. Glebov and M. N. Tolstoi, Fiz. Khim. Stekla 2, 348 (1976).
[5] H. Mackey, H. L. Smith, and A. Halperin, J. Phys. Chem. Solids 27, 1759 (1966).

Translated by Dave Parsons

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